The structure of reasoning and emergence of creative insights in architectural design process

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Abstract: This paper investigates the emergence of creative insights in architectural design processes with an aim to investigate whether there is a recurring pattern between design creativity and cognition. In the design process, *paradigm shifts* and *sudden changes* in the flow of prevailing thoughts are venues of interest to search for creative insights. Our question is: *What is the cognitive context of which the sudden emergence of insights occur in absence of, convergence with, or in conflict with, the preceding established stimulus-responses?*

A design case study is analysed using a descriptive model; linkography protocol is constructed and the gleams of sudden insights (creative notions) are demarcated. Two major recurring patterns of the emergence of insights are perceived: 1) insights appearing in dense linkograph networks with significance to one chief prevailing idea reflects "incremental" thinking process; the concept evolves through accumulative gradual moves of design), while 2) sudden stimulations appear often in the transferral (bridging) nodes between different sub-networks, with high probability to emerge with multiple exchanges of ideas between sketching media. This outcome supports the argument that *breakthrough* ideas result in the collision between two different hunches of thought (i.e. early preceding and late ones) and that no ideas come from nowhere.

Key words: Design Process, Descriptive Model, Creative Insight, Sketching Episodes, Linkograph

1. Introduction

El-Khouly and Penn [1] have developed an integrative model to describe the contents of design process with respect to the *epistemology of practice* and consideration of *designing situations*. The design process is analysed considering cognitive and design actions primary units for segmentation and coding, which made it possible to identify the emergence of sudden creative flashes precisely. This is based on representing the sudden changes occurring on the sketching episodes and transformation in the course of design solution from one state to another. Linkography unveils the structure of design reasoning [2] and [3]. Demarcation of insights on linkographs made it feasible to study the conditions beyond the emergence of sudden flashes and their relationships to the composite pattern of the design process. The application of this methodology on different design case studies (linkograph protocols) made it viable to arrive at the following results:

- If insights emerge within the pattern of one prevailing idea, then it is a result of an *incremental*, *constructive* process, of which the conceptual idea is developed as an accumulation upon the preceding designing steps.
- If insights emerge in the transitional moment between two different ideas (separating between two different networks), then it is considered bridging an earlier hunch of thought with present one giving chance for the collision between two different hunches to occur.

Hence we enquire if the insight is a result of the alternation and mutual exchange(s) between the interim design outcomes (transferring the idea across more than one medium), or is it *out of nowhere, out of the blue? Is it a result of two different hunches of ideas colliding; an old one with the present idea?*

The endeavour to answer these questions led us to develop a model of qualitative assessment, basically depends on the judging the dependency relations between drawings, sketches, non-verbal materials and all interim artefacts of the design process. This appraisal is correlated with the designer's comments that are made retrospectively after ending the process, the evolution of ideas and formation of concepts, and the relationship between sketching episodes and the whole process. Dependency relations are transcribed, coded, and the linkography is constructed according to this model [1]. In order to understand the principles this integrated model is developed on, a highlight on the nature of design problem is presented in light of *rational* versus *design practice* models.

2. The Nature of Architectural Problem and Design Models

There are different proposals of maps and models to analyse the design process. Models are classified between being *rational*; treating the process as technical subject, and models that adopts the epistemology of design practice. Characteristic of the rational models are threefold: a) cyclic, recursive, and periodic; e.g. Jones' model of *'analysis-synthesis-evaluation*' [4], b) *'stages-based*' models are prescriptive, predictable mainstream to happen; e.g. Archer's model of *'analytical-creative-executive*' [5], and c) rational models deal with the environment as a mechanism, relying on *'biological analogy'* and *'natural evolution*'; e.g. *'mutation'* and *'crossover'* [6] and [7]. However, the reliability of rational models to describe ill-defined problems is questioned. Architectural design process is un-specified, un-determined, multileveled, hierarchical and transformative. Dealing with the environment and surrounding context is basically depending on the architect's personal reading, not as pre-known stages, or well-defined parameters. Thus, architecture problem could not be subject to natural biology, evolution rules or genetic mutations aiming at causing changes of genotypes in the same systematic and mechanistic manner.

Of the most important properties of architecture design is that it might be subject to the architect's error interpreting the design programme and making inadequate decisions. The factor of "error" and "undo" actions are considered in some rational prescriptive design models as a stage of evaluation that provides feedback to regenerate the process to an earlier stage, however, most of these models states clearly the cyclic, systemic and recursive manner of the process. This has motivated us to gain empirically based evidence to describe the process with respect to the aspect of *designing situation*; e.g. Darke's model of the prime generator [8] and Schön's model of the reflective practice [9].

Trial-error-correction is a means to a rational reasoning, reflecting a highly structured process to develop the design concept. Considering the aspect of design '*practice*' in empirically based descriptive model enables us to

unveil the structure of reasoning in relation to the architect's idiosyncrasy. In contrast to rational and prescriptive models, a descriptive model is able to include any interpretation, talent and personal skills performed by the architect in relation to the interim product. It aims at understanding the design situation and reckons on Schön's theory of the '*reflective practice*'. Proactive models however, signify a cyclic mandatory nature during the design process regardless to differences of the determinants of reality.

Moreover, the source beyond a design concept can be better revealed in light of influences and personal intentions that aim to develop the conceptual idea. In this context, the metaphors of shapes and forms are utterly described according to the interim outcomes of the design process.

Irrational architectural form is an experimental trend of architecture design. It is based on the epistemology of design practice and might be advanced by relying on computational, generative or parametric, techniques. See figure 1 for some samples of irrational architectural forms that are based on experimentations. This approach of designing raises a question on accidental design ideas and how they refer to creativity.



Figure 1: Samples of irrational architectural forms based on epistemology of design practice and experimentation source: http://www.Arch2O.com/

2. Methodology

A subject designer was invited to design a pavilion for the expo international symposium. The design brief is ill-defined, unstructured and left open-ended to the architect to formulate a problem and generate the best solutions he/she decides. The following procedure was followed to describe the design process and investigate the relations between the interim products:

- Design sketches are transcribed, segmented into episodes, and coded into utterances; see figures 2, 3 and 4.
- Upon the coding model, the dependency relations are established constructing the linkograph, provided in figures 5.
- The linkograph is overlaid with design media; such as sketches, drawings, software application, any graphic material as starting and ending points to show the actions that were pursued in each designing medium, provided in figure 6.
- Demarcation of creative insights on the linkograph's baseline to show the places and venues of change (paradigm shifts) along the process, provided in figure 6.

Hence, our concern on *design novelty* and *emergence of creative ideas* is determined by the aim to
understand the conditions beyond emergence and the context of design reasoning. This can be analysed via
linkograph patterns and correlated with the paradigm shifts between sketching episodes.

2.1 Identification of sketching episodes and design utterances

The series of events that can be observed occurring during the design process are characterised by the sketching episodes and interim artefacts. In this phase, the start and endpoints for each design idea are accurately identified on a unitary based level as well as a global level for conceptual development at every sketching medium included in the design process. Our coding model to decompose the design process into segments to draw the linkograph is macroscopic looking at two levels: a higher level of sketching episodes and a lower level of detailed actions that suddenly occur on the flow of sketching; known as design *utterances*. This model is represented by the following enclosed figures:

Figure 2 presents segmentation for different sketching episodes and types of insights, figure 3 shows coding *dependency* relations amongst different sets of sketching episodes, figure 4 shows identification of sudden changes occurring on the sketching flow that lead to creative insights and different means of transformation of conceptual ideas, figure 5 presents a hypothetical case to code the relations of one idea being developed through two different media sketches (how links can be constructed between two networks), and figure 6 overlays the demarcation of insights on the linkograph protocol.

Archiography is a representation for the dependency relations by looking at the relation between design outcomes and sketching media; e.g. sketches and drawings. It was developed to illustrate the relations in a clearer way than linkography (to avoid dense clusters of nodes not on the baseline; replaced with arcs). Archiography draws links between the related utterances in relation to their designing medium. It enables us to inspect the role of multiple switches between different products/sketches and the emergence of sudden insights. It supports our investigation on the connectivity of linkograph to describe the structure of events via different spectrum of states: *orderliness* versus *disorderliness*. *Archiographer*© is a software aims at building up the relationships and draw the archiograph [1] and [3].

- <u>Segmentation</u>: is a sketch-based model; a "one-go" sketching activity is considered an episode that might comprise more than one utterance or in some cases the whole sketching episode is considered as one utterance in the linkograph if it has been made without any transformation of the idea and without any pauses of activity. Nodes can be identified in the following cases:
 - Reflections on artefacts: reflection-in-action with the interim outcomes of design that changes the flow of sketching and transforms the idea is expected to bisect designing activity into a series of sketching episodes and utterances.
 - Idiosyncratic actions: thinking-pauses, gestures, switching design tools, exchanging sketches (alternations), back-fore linking ideas, flipping drawings around, tracing over, and rescaling are all counted as design utterances (moves).
 - Ethnographic analysis of verbal protocols: searching for conceptual phrases and keywords, finding any common relation between design utterances and confirmation words, Q/As, sentences that explain the design concept(s) are also checked in this model.

- Coding: design moves are coded based on types of contribution into the creative process. Two major sets are included: 1) actions that preserve "continuous" reflections with the mind, and 2) actions that "defy" continuous reflections and transform the process instead. *Preserving* reflection proceeds on the initial former concept, taking various forms of activity; such as: *replication*, *redefinition*, or *advanced incrementation*. *Defying* reflection introduces a new item to the current state of design, owing taxonomy of actions that change and restructure the whole design situation; such as: *divergence*, *synthesis* and *reconstruction*.
- Linking sketching episodes: This model operates on a macroscopic scale of coding the design process in terms of sketching episodes. Each drawing projection, diagram, or scribble is treated as a single sketching episode. Episodes that might contain sub-categorical minor or tiny detailed actions are uncounted in order to preserve the characteristic of a hierarchical structure of reasoning and to avoid scaling the process into micro "floored" or "granular" level that loose the meaning of coding the dependency relations. Throughout drawing actions, the designer might add tiny details to the sketch that are meaningless to count; for instance: drawing few working lines, scribbles, and so forth. Once the sketching episodes are transcribed into single units, perceptual relations and comparisons and searched for to find any commonalities.
- Linking drawings and thoughts between different sketching media: dependency-relations occur when the designer switches design actions and retrieve knowledge from one sketch to another. This switch might be: an intent for enhancing an earlier drawing, continuing on the former flow, reflecting on the idea by adding details of more elements, drawing another projection of the idea, or on contrary, changing the whole flow to a wholly different concept.

A medium sketch has starting and ending points. It begins when setting up the medium to draw and ends when the designer switches to another one. Interactions, iterations on the sketch, and scribbles can be tracked via certain nodes to investigate their relations with the following medium.

A design concept starts by doodling an idea, extending the concept to explore different aspects, adding more details, then presenting and lining up the whole artefact with shadows and colours, etc. In case of tracing over a sketch, the second medium has relations with most of the drawing actions that were made on the first one (tracing reference). Thus, it has relations with one or more points in addition to the starting point of the first sketch.

2.2 Identification of creative insight:

Our identification of the series of events of sketching episodes; to become the unitary bases constructing the linkograph, is accord with the Goldschmidt's method to recognise a design move/step. Goldschmidt [10] defines a design move as: 'a step, an act, or an operation that transforms the design situation relative to the state in which it was prior to that move.' The sketching episode is a transformation in the perception occurring in the designer's mind from one state to another. It happens while marking out the drawings prior to the design situation as well as to the interim reflections with the sketch in progress. Detection of insights is rendered by the framework that was articulated by Akin and Akin's [11] of which creative insights are: 'Any sign on perceiving a notion to break out a frame of reference [FR] and shift to a new one to overcome a fixation effect is considered a sudden mental insight.

Schön [12] however, states that the formation of new concepts is: 'A displacement of ideas from old situations to new ones.' Johnson [13] states that 'good ideas come from a collision of two hunches; one is incubated in the

mind (might take many years) and one is present.' A creative insight moves the perception completely to a different state that is independent from the current design situation. Design moves are categorised according to their contribution to the process into two main categories; forming two sets of contribution: 1) actions preserving the continuous reflection with the mind, and 2) actions defying the continuous reflection with the mind. Preserving actions cause *convergence* of the conceptual idea while defying actions cause *divergence* of the conceptual idea.

3. Hypothesis

Two primary processes of design reasoning are hypothesised for our investigation, the former is incremental reasoning where design actions are interrelated and centred on one prevailing idea but is developed in a sequence of steps; reframing the solution. The latter is a process of restructuring the design problem from one state to another with an aim to develop a unique conceptual idea. The emergence of creative insights can happen with both processes of reasoning. We propose the following indicative aspects to investigate the impact of the structure of reasoning on the transformation of ideas and the emergence of creative insights: 1) whether the emergence of creative insights is dependent on how the design situation is structured and interrelated, or 2) the emergence of creative insights is independent from the situation but basically relies more on the ability to *restructure* the situation of the design problem. In both cases, we ask: what is the role of multiple switches between one sketching medium to another? Knowing that, hypothesis 1 signifies an incremental process while hypothesis 2 owes more to a process with a sudden incidental nature.

4. Design Experiment, Descriptions, and Analysis

An experiment to design an expo-pavilion presenting the image of your country on your own perspective is requested. The brief is left open-ended, with no specific requirements or constraints, giving the designer free rein to present the conceptual idea via any means of representation, without specific drawings or projections and with no intrusion from the researcher/ethnographer. In a time of one hour, the design process is video-recorded and the architect is asked consequently to comment back on the concept and transformation of ideas for the serial order of sketches produced in the process.

The concept of our experimental case is based on the congregation of five pavilions. The design process commenced bottom-up way by setting up key conceptual elements of Greece (Greek pavilion), such as: *sunlight*, *rocks*, the *blue-sky colour*, *water ponds*, *interlocking stepped forms*, *olive and lemon trees*, *cubic forms* and *shadows*. The architect proceeded then to synthesise the concept of each pavilion around these conceptual elements where some were repeated in more than one pavilion but with different treatments; e.g. using natural skylights, light wells as well as artificial lighting and interactive installations.

Pavilion 2 for instance, was designed on the concept of the synthesis of *sunlight, cubic stepped and linked forms*, and the *olive tree* in the centre of the pavilion. The concept was developed through two media sketches with different projections: 2D plan and 3D perspective section. The idea was transformed and developed by switching back-and-forth three times between the two sketches. Switching points are shown in figure 6; the starting node of switching from pavilion 1 to pavilion 2: 23, the entire switching nodes: 27, 30, 47, and the ending node is: 52. At pavilion number 4, nodes 71 to 78, a novel idea stroke over the former flow and restructured the

whole design situation. It splits the linkograph into two sub-networks; having totally independent design concepts, see figure 6.

5. Results and Discussion

This process started with an *insightful* phase where the concept is initiated by setting up some key elements to build the design idea on. Some conceptual elements emerged in a surprising way, reflecting vertical and sudden changes on the flow of sketching. This appeared at nodes 2 to 8, 11 and 15; all were designed in the same sketching medium no.1. The designer thereafter switched to another sketching medium no.2, and designed the first pavilion of five; pavilion 1 is called *'interlocking stepped forms.'* Nodes 17, 18, and 19 are considered incremental mode of reasoning built on one prevailing idea. Each node represented different treatment; node 17 is a 3D perspective, node 18 is a 3D perspective section, and node 19 is a 2D plan. Any refining details on these three projection drawings were not counted segments or utterances to preserve the structure of reasoning being floored. Nodes 17, 18, and 19 are considered incremental creative insights, although reframing an architectural treatment but all are interrelated and coded as "*advanced incrementation.*." Nodes 25, 27, and 31 reflect three entire switches between different sketching episodes for one former concept for the *olive tree* pavilion. These nodes are considered a vertical transformation on the conceptual idea from one drawing to another, thus, representing incremental mode of reasoning.

Goldschmidt states two kinds of sketching [10]; one aims to transform imagery into forms and drawings (rational mode of reasoning), and another sketching type aims to generate new imagery of forms in the mind (nonrational form of thinking). Node 52 is a *back reflection* action; a new conceptual element was added to the set of early concept initiation. The idea is for *irrational openings* and *balconies* that distinguish Greek's architecture. At node 55 however, a sudden change from the precedent occurred. Switching the design to pavilion no. 3, a novel concept emerged for the *lighting tunnel* pavilion. It is an artificial interactive installation centred on the concept of *lighting* and *fade*. Node 60 is another switch within the former idea of pavilion 3; a transformation to design 2D longitudinal-section. Thus, node 55 is considered a sudden creative insight that structured the following actions in the sketching medium.

Node 71 is a sudden insight, the designer shifts to draw an un-preceding conceptual element about the immigration of Greeks around the world, representing the concept of pavilion 4 in the form of *interactive installations*. The architect commented back on this notion as inspired from the *Zumba* Serpentine pavilion, saying: '*I am also influenced by the Zumba Serpentine Gallery Pavilion, which has everything in black and it has to do with light*' (a retrospective comment). The process was then proceeded (continued) through another projection medium sketch -3D section at shifting node no. 72.

Finally, pavilion 5 is a different concept of the precedent, revolves around the elements of *rocks* and *water*, covered by a skylight, started from node 79. This insight although reflects synthesis with an old key element in the concept initiation phase, node 11 (rock and water) however it is considered a change occurring on the preceding flow. Node 82 is a *forward incrementation* move for the former idea but on a different sketching medium 3D perspective section. Table 1 illustrates the impact of the resulted modes of reasoning, *incrementation* versus *restructuring*, and the role of multiple switches of media on the emergence of sudden creative insights.

According to these results, we argue that modes of reasoning that have a direct impact on the emergence of creative insights are twofold: The former is the incrementation process where insights occur on the same former prevailing concept. This can be supported by the transformation of idea throughout projections; entire switches between 2D and 3D drawings, and is likely to occur with a dense pattern in the linkograph. The latter type restructures the whole design problem, changes the design situation and the concept, where insights occur suddenly with no relation to the precedent actions. However, a sudden insight might emerge through the collision with an old hunch, such as building synthesis with an old idea, form, or element. This is supported by switching media from one concept to another, from one problem state to another. It often appears in the linkograph as a bridging node between two patterns; a transferral vertex of two sub-networks. It is distinguished of its "long" back-fore linking between an earlier thought and a present one in the linkograph. This type diversifies the design process and sources of formulating the concept. It constitutes *divergent* thinking that is considered a capacity for design creativity [14]. El-Khouly and Penn [3] investigated the characteristics of the different states of design through the patterns of linkograph. Two primary states are identified: orderliness and disorderliness. A structured state is placed in between both states. It is worthwhile mentioning that media switches can be used in some processes to retrieve knowledge or information from an old sketching medium (i.e. tracing a form/shape from an old drawing, retrieving information, perceiving spatial organisation... etc.), in which structures knowledge of the design process and rationalise modes of thinking. Design is a 'knowledge-based process' [15] Setting forms of retrieving and displacing knowledge through the process structures the emergence of insights along the way. Thus, multiple exchanges of information between different media structures design creativity and underpin the emergence of insights to certain venues. The process becomes incremented, unless the support sudden emergence of creative insights re-structures the whole design situation and changes the former concept to a novel one.

Medium	Concept	Significant Nodes		
		Entire Switching Nodes	Media Switching Nodes	i ne impact of the structure of reasoning on the emergence of insights
Conceptual set	Elements of the image of a country	2, 3, 4, 5, 6, 7, 8, 11, 15	24, 25, 52, 71	Incremental insights – except 24, 52, and 71 is sudden back reflection to the mind
Pavilion 1	Interlocking stepped forms	17, 18, 19	_	Incremental insights and entire switches of one former concept
Pavilion 2	Olive tree	27, 31	26	26 is a sudden insight while 27 and 31 are incremental insights; constitute entire switches of one former concept
Pavilion 3	Lighting tunnel	60	55	55 is a sudden insight while 60 is an incremental insight; entire switch
Pavilion 4	Links and cities	72	71	71 is a sudden insight while 72 is an incremental insight; an entire switch of a former concept
Pavilion 5	Rocks and water	82	79	79 is a sudden insight while 82 is an incremental insight; an entire switch of a former concept

Table 1: Descriptions of the types of reasoning and emergence of insights during the design process:

6. Conclusions

This paper contrasts the *emergence of creative insights* versus *patterns of design reasoning* using *linkography*. Two modes of reasoning are hypothesised and investigated throughout the empirical study: *incremental* and *restructuring* processes. Creative stimulations occur in both contexts. Dependent insights on the design situation occurring on the same former prevailing concept are *incremental*, representing *vertical transformation* throughout detailing different projections. They are likely to occur in dense structured networks in the linkograph. Some insights are even considered *advanced forward incrementation* of the prevailing idea.

The second reasoning type is *restructuring* the design problem, state or situation. Independent insights from the context of preceding nodes are *sudden*, occurring suddenly with no relation to the preceding actions. Multiple switches of sketching media and interim products stimulate the emergence of sudden, un-predicted, creative insights that appear in the transition or bridging nodes between two different chunks of thoughts. An *insightful* process is distinguished of its "long" back-fore linking between earlier thoughts and present ones, representing a bottom-up thinking process. This type of insights diversifies the process with various sources for conceptual formulation and constitutes *divergence thinking* as a capacity for design creativity.



Figure 2: Snapshots of segmenting sketching episodes and types of insights



Figure 3: Snapshots of coding the dependency relations amongst different sets of sketching episodes



Figure 4: Snapshots of identifying sudden changes occurring on the sketching flow – creative insights leading to different means of the transformation of the conceptual idea



Figure 5: A hypothetical case study of coding the relations between the design utterances of one former idea being developed through two different media sketches (the dependency relations are investigated between two networks)



Figure 6: Linkograph overlaid with archiography of designing media, sketching episodes (starting and endpoints) and demarcation of creative insights

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